21

CLAIMS

1. An apparatus for fetal monitoring comprising:

a) means for determining a fetal heart rate,

b) means for identifying a primary fetal heart rate component which is required to shift a volume of blood from the heart to the cardiovascular system,

c) means for subtracting the primary component from the determined fetal heart rate to determine a residual component; and

d) means for using said residual component for analysis of the fetal heart rate beat-to-beat variation.

2. An apparatus as claimed in claim 1, wherein the primary fetal heart rate component is identified through a polynomial curve fit approximation of the fetal heart rate data.

3. An apparatus as claimed in claim 1, wherein said means for identifying the primary fetal heart rate component is adapted to perform the following steps:

i)   linear interpolation of recorded fetal heart rate data;

ii)   resampling at a resampling frequency, thereby forming a resampled series of fetal heart rate data, and;

iii)   polynomial curve fit approximation of said resampled series.

4. An apparatus as claimed in claim 2 or 3, wherein the polynomial curve fit approximation utilises polynomials of at least the 5th order.

22

5. An apparatus as claimed in claim 4, wherein said polynomials are of the 5th order.

6. An apparatus as claimed in claim 4, wherein said polynomials are of the 12th order.

7. An apparatus as claimed in any one of claim 2 to 6, wherein the polynomial approximation is obtained through a least squares approximation.

8. An apparatus as claimed in any preceding claim, wherein the primary fetal heart rate component is determined by:

i)   dividing the fetal heart rate data into regions of a predetermined size; and

ii)   performing individual polynomial approximations in each region.

9. An apparatus as claimed in claim 8, wherein each polynomial approximation is constrained such that neighbouring polynomial functions align and have equal first derivatives at the region border where they join.

10. An apparatus as claimed in claim 8 or 9, wherein the predetermined size is greater than or equal to 20 consecutive heart rate samples.

11. An apparatus as claimed in claim 10, wherein the predetermined size is 20 consecutive heart rate samples.

12. An apparatus as claimed in any preceding claim, wherein the means for using said residual component for analysis of the fetal heart rate beat-to-beat variation

is adapted to apply statistical tests for analysing the
residual component in order to determine the response of
the fetus.

5   13. An apparatus as claimed in claim 12, wherein the
statistical test comprises monitoring of a 95th percentile
of the fetal heart rate residual component.

14. An apparatus as claimed in claim 13, wherein the
10   statistical test further comprises calculating a median
and a variance of said 95th percentile over a
predetermined period of time.

15. An apparatus as claimed in claim 14, wherein said
15   predetermined period of time is longer than 10 minutes.

16. An apparatus as claimed in any one of claims 13 - 15,
wherein if the median of the 95th percentile is
consistently below 3ms the fetal heart rate is classed as
20   abnormal and non-reactive.

17. An apparatus as claimed in any one of claims 12 - 15,
wherein said means for using said residual component for
analysis of the fetal heart rate beat-to-beat variation
25   is adapted to indicate a significant reduction of fetal
reactivity given a recording of the median of the 95th
percentile below 2.3 ms and the variance of the 95th
percentile below 0.1 over an extended period of time.

30   18. An apparatus as claimed in any one of claims 12 - 15,
wherein said means for using said residual component for
analysis of the fetal heart rate beat-to-beat variation
is adapted to indicate a significant reduction of fetal

24

reactivity given a recording of a decreasing trend of the
median of the 95th percentile over an extended period of
time.

5   19. An apparatus as claimed in any one of claims 12 - 15,
wherein said means for using said residual component for
analysis of the fetal heart rate beat-to-beat variation
is adapted to exclude an abnormally low fetal heart rate
variation if the median of the 95th percentile is
10   consistently above 3ms.

20. An apparatus as claimed in claim 12, wherein the
statistical test comprises monitoring of a short term,
e.g. 3-4ms, frequency distribution of the fetal heart
15   rate residual component.

21. An apparatus as claimed in claim 20, wherein if a 3-
4ms frequency distribution is less than 7% the fetal
heart rate is classed as non-reactive.
20

22. A method for fetal monitoring comprising the steps
of:
a) determining a fetal heart rate,
b) identifying a primary fetal heart rate component which
25   is required to shift a volume of blood from the heart to
the cardiovascular system,
c) subtracting the primary component from the determined
fetal heart rate to determine a residual component; and
d) using said residual component for analysis of the
30   fetal heart rate beat-to-beat variation.

23. A computer program for executing the steps of:
a) determining a fetal heart rate,

b) identifying a primary fetal heart rate component which
is required to shift a volume of blood from the heart to
the cardiovascular system,

c) subtracting the primary component from the determined

5   fetal heart rate to determine a residual component; and

d) using said residual component for analysis of the
fetal heart rate beat-to-beat variation.

10